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Recent Seven Years of Radio and Optical Variabilities of Quasar 1156 + 295

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Abstract. We analyzed the radio (4.8, 8.0 and 14.5 GHz) light curves from UMRAO database and the optical data of quasar 1156 + 295 and found that the quasar exhibited remarkable quasi-periodic long-term flux variations in both radio and optical bands with a similar variability timescale of 1.2 ± 0.3 yr. In addition, when a cross correlation analysis was adopted to the radio and optical light curves, we found that the optical variations may precede those of the radio e.g., at 14.5 GHz by $\sim$200 days.

Key words. Quasar: individual: 1156 + 295—long-term variability.

1. Light curves

The radio data of quasar 1156 + 295 at 4.8 8.0, and 14.5 GHz are from the University of Michigan Radio Astronomy Observatory (UMRAO) during 2005 to June 2012. R-band optical data are from LX-200 and AZT-8 (http://www.astro.spbu.ru/staff/vlar/OPTlist.html) in the same period. We analysed the radio and optical data of 1156 + 295 for the past 7 years. The light curves are shown in Figure 1(a), which show quasi-periodic flares at three radio bands with some time delay from higher to lower frequencies, and the optical flares seem to precede the radio flares.

2. Variability analysis and results

The characteristic timescale of the light curves were estimated with the first-order structure function (Simonetti *et al.* 1985). In Figure 1(b), the structure functions (SF) exhibited a similar shape for both the radio and the optical data. The major plateau in the SF plot indicates the characteristic timescale, which corresponds to the 'peak-to-trough' timescale of a quasi-periodic variability. The resulted characteristic timescale

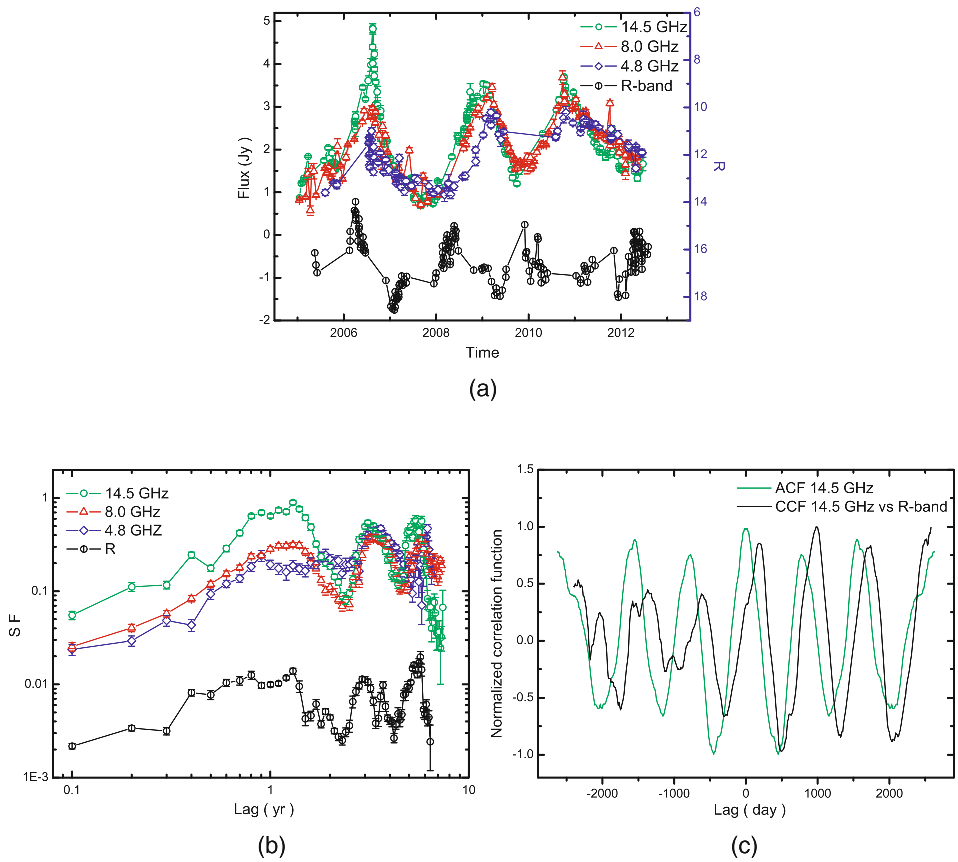

Figure 1. (**a**) Light curves at the radio and optical R-band of 1156 + 295. (**b**) Structure functions for the radio and optical R-band of 1156 + 295. (**c**) Discrete autocorrelation function for 14.5 GHz data (green), and discrete cross-correlation function between the radio 14.5 GHz and optical R-band data (black).

is 1.2 ± 0.3 yr for both radio and optical light curves, and it also implies a possible quasi-periodic variability period of $\sim 2.4 \pm 0.6$ yr. We also applied the method of discrete correlation function (Edelson & Krolik 1988) to the radio data. The autocorrelation function at 14.5 GHz (Figure 1(c)) indicated a clear periodic variability of 2.5 ± 0.3 yr, which is consistent with the variability period estimated from the structure functions. The cross-correlation function between the radio and R-band optical data in Figure 1(c) suggested that the optical variations may precede those of radio e.g., at 14.5 GHz by $\sim$200 days.

Time delays of radio flux variations in different bands have also been found, and those time delays can be explained with the opacity effect, for flare becomes optically thin more earlier at higher frequency than at lower frequency. To understand the time delay from optical to radio variations, we need to know where the optical variations come from, e.g., from the jet, the accretion disk, or the broad line region of AGNs. We will investigate this in the future.

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